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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/732,177	12/07/2000	Kenichi Hasegawa	116-002064	1420

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David C. Hanson
WEBB ZIESENHEIM LOGSDON ORKIN & HANSON, P.C.
700 Koppers Building
436 Seventh Avenue
Pittsburgh, PA 15219

EXAMINER	
SHARON, AYAL I	
ART UNIT	**PAPER NUMBER**
2123	9

DATE MAILED: 06/02/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)
	09/732,177	HASEGAWA, KENICHI
	Examiner	Art Unit
	Ayal I Sharon	2123

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 10 March 2004.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-12 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-12 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on 3/10/04 is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☒ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Introduction

1. Claims 1-12 of U.S. Application 09/732,177 originally filed on 12/07/2000 are presented for examination. In paper #7, filed 3/10/2004, Applicants have amended the specification, Claims 1-3, 5, and 7-11, in addition to amending the drawings for figures 1, 2, 3(a), 3(b), 4(a), 4(b), and 7.

Priority

2. Acknowledgment is made of applicant's claim for foreign priority based on an application filed in Japan on 12/07/1999. It is noted, however, that applicant has not filed a certified copy of the Japanese application as required by 35 U.S.C. 119(b).

Claim Objections

3. Claims 1-12 are objected to because of the following informalities: Independent claims 1 and 7 have been amended, and a new spelling error has been introduced. Examiner has added a new objection to "field distortions cause by eddy currents", which should be "field distortions cause<u>d</u> by eddy currents". Appropriate correction is required.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. The prior art used for these rejections is as follows:

6. Schenck, J.F. et al. "Formulation of Design Rules for NMR Imaging Coil by Using Symbolic Manipulation." Proc. of the 4th ACM Symposium on Symbolic and Algebraic Computation. 1981. pp.85-93. (Henceforth referred to as "**Schenck**").

7. Ishibashi, K. "Nonlinear Eddy Current Analysis by the Integral Equation Method." IEEE Transactions on Magnetics. Sept. 1994. Vol. 30, Issue 5. pp.3020-3023. (Henceforth referred to as "**Ishibashi**").

8. The claim rejections are hereby summarized for Applicant's convenience. The detailed rejections follow.

9. **Claims 1-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Schenck in view of Ishibashi, and further in view of Official Notice.**

10. In regards to claim 1: 1. A method of designing a magnetic field gradient coil assembly using tightly wound inner and outer coils, said method comprising the steps of:

setting or resetting the number of said inner coils and optimizing their positions such that a resulting magnetic field strength falls within a tolerable range of a target magnetic field gradient under shielded conditions;

setting or resetting the number of said outer coils and the number of turns of each outer coil;

calculating Fourier components of an electric current distribution necessary for the outer coils;

optimizing positions of the outer coils to approximate the Fourier components of the current distribution;

calculating magnetic fields leaking from the inner and outer coils, respectively;

calculating magnetic field distortions caused by eddy currents produced by the leaking magnetic fields; and

resetting the number of the outer coils and the number of turns of each outer coil if the magnetic field distortions are outside the tolerable range.

Schenck teaches a method of designing a magnetic field gradient coil assembly using coils "... that will produce a given magnetic field." (Schenck, p.85, 1st para.). Schenck also teaches that "the natural mathematical approach to this problem is to introduce some form of series expansion of the field, wherein the expansion coefficients are functions of the configuration of the coil." (Schenck, p.85, col.1, 2nd para.).

However, Shenck does not expressly teach:

1) the use of inner and outer coils,

2) that the resulting field strength "falls within a tolerable range of a target magnetic field gradient under shielded conditions", as claimed,

3) setting a number of inner or outer coils, nor the number of turns of each coil,

4) the use of Fourier components,

5) the calculation of leaking fields,

6) field distortions caused by eddy currents, nor

7) resetting the number of outer coils and number of turns of each outer coil if the magnetic field distortions are outside the tolerable range.

Ishibashi, on the other hand, does teach the features 2) –7) listed immediately above (See Ishibashi, Abstract and "I. Introduction"). More specifically, Ishibashi teaches "surface magnetic fields given as boundary values". This is element 2). Ishibashi also teaches that "...the quantities are

expanded by Fourier series..." This is element 4). Ishibashi also teaches "surface and internal [magnetic] fields", that are equivalent to the "leaked fields" in feature 5). Ishibashi also teaches the field effects of eddy currents. This is element 6).

Ishibashi also teaches that the technique is "iterative". (See Ishibashi, "I. Introduction"), therefore teaching the "setting" and "resetting" components of features 3) and 7) listed immediately above. Moreover, it is inherent that the number of coils, and the number of turns per coil, will have an effect on the EMF, and therefore that these will be the parameters that are adjusted.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Schenck with those of Ishibashi because "the boundary element method (BEM) has been widely used for analyzing open boundary eddy current problems" and "... it is well known that even BEM can be applied to the analysis of nonlinear problems." (See Ishibashi, "I. Introduction").

Official Notice is given that it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Schenck by using inner and outer coils, (as claimed in feature 1) of the list of features not taught by Schenck), because doing so would enable creating EMF paterns that cannot be created by using only one layer of coils.

11. In regards to claim 2:

> 2. A method of designing a magnetic field gradient coil assembly as set forth in claim 1, wherein said step of setting or resetting the number of said inner coils and optimizing their positions such that a resulting magnetic field strength falls within a tolerable range of a target magnetic field gradient under shielded conditions uses a Green function.

Schenck does not expressly teach the use of Green's theorem in order to set, reset, and optimize the positions of the inner coils.

Ishibashi, on the other hand, does expressly teach this. (See Ishibashi, Abstract, "I. Introduction").

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Schenck with those of Ishibashi because "the boundary element method (BEM) has been widely used for analyzing open boundary eddy current problems" and "... it is well known that even BEM can be applied to the analysis of nonlinear problems." (See Ishibashi, "I. Introduction").

12. In regards to claim 3:

> 3. A method of designing a magnetic field gradient coil assembly as set forth in claim 1, wherein said step of calculating Fourier components of an electric current distribution necessary for the outer coils uses a Green function.

Schenck does not expressly teach the use of Green's theorem in order to set, reset, and optimize the positions of the outer coils.

Ishibashi, on the other hand, does expressly teach this. (See Ishibashi, Abstract, "I. Introduction").

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Schenck with those of Ishibashi because "the boundary element method (BEM) has been widely used for analyzing open boundary eddy current problems" and "... it is well known that even BEM can be applied to the analysis of nonlinear problems." (See Ishibashi, "I. Introduction").

13. In regards to claim 4:

> 4. A method of designing a magnetic field gradient coil assembly as set forth in claim 1, wherein said step of optimizing the positions of the outer coils to approximate the Fourier components of the current distribution performs the approximation using a small number of tightly wound coils.

While Schenck teaches that "... the natural mathematical approach to this problem is to introduce some form of series expansion of the field, wherein the expansion coefficients are functions of configuration of the coil." (See Schenck, p.85, col.1, 2nd para.). However, Schenck does not expressly teach the use of the Fourier series or Fourier components.

Ishibashi, on the other hand, does expressly teach the use of Fourier series, to model the "periodic electromagnetic quantities in the conductor". (See Ishibashi, Abstract, "I. Introduction"). It is inherent in a Fourier series that each additional element produces diminishing improvements in the results.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Schenck with those of Ishibashi because "the boundary element method (BEM) has been widely used for analyzing open boundary eddy current problems" and "... it is well known that even BEM can be applied to the analysis of nonlinear problems." (See Ishibashi, "I. Introduction").

14. In regards to claim 5:

> 5. A method of designing a magnetic field gradient coil assembly as set forth in claim 1, wherein said step of calculating magnetic fields leaking from the inner and outer coils, respectively, and said step of calculating magnetic field distortions caused by eddy currents produced by the leaking magnetic fields use a Green function.

Schenck does not expressly teach the use of Green's theorem in order to calculate magnetic field distortions caused by eddy currents.

Ishibashi, on the other hand, does expressly teach this. (See Ishibashi, Abstract, "I. Introduction").

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Schenck with those of Ishibashi because "the boundary element method (BEM) has been widely used for analyzing open boundary eddy current problems" and "... it is well known that even BEM can be applied to the analysis of nonlinear problems." (See Ishibashi, "I. Introduction").

15. In regards to claim 6: 6. A method of designing a magnetic field gradient coil assembly as set forth in claim 1, wherein said step of resetting the number of the outer coils and the number of turns of each outer coil if the magnetic field distortions are outside the tolerable range, said step of calculating Fourier components of an electric current distribution necessary for the outer coils, said step of optimizing the positions of the outer coils to approximate the Fourier components of the current distribution, said step of calculating magnetic fields leaking from the inner and outer coils, respectively, and said step of calculating magnetic field distortions caused by eddy currents produced by the leaking magnetic fields are repeatedly carried out to determine optimum conditions for the outer coils by trial and error.

Schenck does not expressly teach that the steps are repeatedly carried out to determine the optimum conditions.

Ishibashi, however, teaches that the technique is "iterative". (See Ishibashi, "I. Introduction").

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Schenck with those of Ishibashi because "the boundary element method (BEM) has been widely used for analyzing open boundary eddy current problems" and "... it is well known that

even BEM can be applied to the analysis of nonlinear problems." (See Ishibashi, "I. Introduction").

16. In regards to claim 7: 7. A magnetic field gradient coil assembly having tightly wound inner and outer coils, said magnetic field gradient coil assembly having been designed by a method comprising the steps of:

setting or resetting the number of said inner coils and the number of turns of each inner coil and optimizing their positions such that a resulting magnetic field strength falls within a tolerable range of a target magnetic field gradient under shielded conditions;

setting the number of said outer coils and the number of turns of each outer coil;
calculating Fourier components of an electric current distribution necessary for the outer coils;
optimizing positions of the outer coils to approximate the Fourier components of the current distribution;
calculating magnetic fields leaking from the inner and outer coils, respectively; and
resetting the number of the outer coils and the number of turns of each outer coil if the magnetic field distortions are outside the tolerable range.

Schenck teaches a method of designing a magnetic field gradient coil assembly using coils "... that will produce a given magnetic field." (Schenck, p.85, 1st para.). Schenck also teaches that "the natural mathematical approach to this problem is to introduce some form of series expansion of the field, wherein the expansion coefficients are functions of the configuration of the coil." (Schenck, p.85, col.1, 2nd para.).

However, Shenck does not expressly teach:

1) the use of inner and outer coils,

2) that the resulting field strength "falls within a tolerable range of a target magnetic field gradient under shielded conditions", as claimed,

3) setting a number of inner or outer coils, nor the number of turns of each coil,

4) the use of Fourier components,

5) the calculation of leaking fields,

6) field distortions caused by eddy currents, nor

7) resetting the number of outer coils and number of turns of each outer coil if the magnetic field distortions are outside the tolerable range.

Ishibashi, on the other hand, does teach the features 2) –7) listed immediately above (See Ishibashi, Abstract and "I. Introduction"). More specifically, Ishibashi teaches "surface magnetic fields given as boundary values". This is element 2). Ishibashi also teaches that "…the quantities are expanded by Fourier series…" This is element 4). Ishibashi also teaches "surface and internal [magnetic] fields", that are equivalent to the "leaked fields" in feature 5). Ishibashi also teaches the field effects of eddy currents. This is element 6).

Ishibashi also teaches that the technique is "iterative". (See Ishibashi, "I. Introduction"), therefore teaching the "setting" and "resetting" components of features 3) and 7) listed immediately above. Moreover, it is inherent that the number of coils, and the number of turns per coil, will have an effect on the EMF, and therefore that these will be the parameters that are adjusted.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Schenck with those of Ishibashi because "the boundary element method (BEM) has been widely used for analyzing open boundary eddy current problems" and "… it is well known that even BEM can be applied to the analysis of nonlinear problems." (See Ishibashi, "I. Introduction").

Official Notice is given that it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the teachings of Schenck by using inner and outer coils, (as claimed in feature 1) of the list of features not taught by Schenck), because doing so would enable creating EMF paterns that cannot be created by using only one layer of coils.

17. **Claims 8-12 are rejected based on the same reasoning as claims 2-6. Claims 8-12 are magnetic field gradient coil assembly claims reciting the equivalent limitations as are recited in method claims 2-6 and taught throughout Schenck and Ishibashi.**

Response to Amendment

Re: Information Disclosure Statement

18. Examiner thanks the Applicants for providing the paper by P. Mansfield and B. Chapman, "Multi-shield Active Magnetic Screening of Coil Structures in NMR", J. Magn. Reso. Vol.72, 1987, pp.211-223, which is cited in p.1 of the specification.

Re: Drawings

19. Examiner acknowledges Applicant's corrections of Figs. 4(a)-4(b) and 7 to read "Green's" instead of "Green". Moreover, Examiner acknowledges Applicant's amendment to Figs.1-4(b), which are now designated "Prior Art".

20. Applicant argues (paper #7, p.7. Filed 3/10/04) that Figs. 5(a)-6 are "used for illustrating embodiments of the present invention, and therefore should not be

labeled "Prior Art". Examiner accepts Applicant's argument, and therefore has withdrawn the objection that required these figures to be labeled as "Prior Art".

Re: Specification

21. Examiner acknowledges Applicant's amendment to the specification that replaced the term "Green function" with "Green's function". The objection to the specification has therefore been withdrawn.

Re: Claim Objections

22. Examiner acknowledges Applicant's amendment to Claims 2, 3, 5, 8, 9, and 11 by replacing the term "Green function" with "Green's function". The objection has therefore been withdrawn.
23. Claims 1 and 7 have been amended, and a new spelling error has been introduced. Examiner has added a new objection to "field distortions cause by eddy currents", which should be "field distortions cause<u>d</u> by eddy currents".

Re: Claim Rejections - 35 USC § 112

24. Examiner acknowledges Applicant's amendment of Claims 1 and 7 by deleting the word "tightly" from the term "tightly wound ... coils". Examiner has therefore withdrawn the 35 U.S.C. 112, first paragraph associated with the word "tightly".
25. Applicant argues (paper #7, p.8. Filed 3/10/04) that Equations 8-11 on pp.4-5 of the original specification provide enablement for the claimed "Fourier

components are used in combination with Green's theorem", as claimed in Claims 2, 3, 5, 8, 9, and 11. Examiner has found Applicant's argument to be persuasive and has withdrawn the rejection.

Re: Claim Rejections - 35 USC § 103

26. The Applicant argues (paper #7, pp.8-9. Filed 3/10/04) that:

> As pointed out by the examiner, Ishibashi teaches the method of calculating magnetic fields caused by nonlinear eddy currents by using Green's function and iterative method. However, the purpose of Ishibashi's calculation is to obtain magnetic fields. On the other hand, the purpose of Applicant's calculation is to determine the number of outer coils and the number of turns of each outer coil that reduce magnetic field distortions caused by eddy currents to within the tolerable range. Ishibashi does not teach the method of reducing magnetic field distortions caused by eddy currents to within tolerable range.

27. Examiner stated in the original rejections of independent claims 1 and 7 that

> "Moreover, it is inherent that the number of coils, and the number of turns per coil, will have an effect on the EMF, and therefore that these will be the parameters that are adjusted."

Examiner is maintaining this argument. The following are citations in the prior art that support this position.

28. The McGraw-Hill Dictionary of Electrical and Electronic Engineering (1984) teaches the following definition for the term "coil" (see p.65):

> A number of turns of wire used to introduce inductance into an electric circuit, to produce magnetic flux, or to react mechanically to a changing magnetic flux; in high-frequency circuits a coil may be only a fraction of a turn. Also known as electric coil; inductance; inductance coil; inductor.

29. The Electrical Engineer's Reference Book, 14th Ed. (1985) teaches the following regarding eddy currents and coil windings (see p.14/11, section 14.3.4 "Losses"):

> The load (or 'copper') loss comprises two components: a direct I^2R loss due to the ohmic resistance of the windings, and a stray loss arising from eddy currents in the conductors due to their own flux, influenced by tank and by steel clamping structures. The eddy loss is negligible when the section of the conductors is small.

Examiner notes that coils with longer winding will have a larger ohmic resistance "R".

30. The Fields and Waves in Communications Electronics (1984) teaches the following regarding magnetic field and the number of turns (p.191):

> For the other extreme, the inductance of a very long solenoid (Fig.4.8b) may be computed. If the solenoid is long enough, the magnetic field on the inside is essentially constant, as for the infinite solenoid:
>
> $H_z = (N^*I) / L$
>
> where N is the total number of turns and L the length. The flux linkages for N turns is then $N\pi R^2\mu H_Z$, and the inductance is
>
> $L_0 = ((\pi R^2N^2)/L) * H$

Conclusion

31. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will

the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Correspondence Information

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ayal I. Sharon whose telephone number is (703) 306-0297. The examiner can normally be reached on Monday through Thursday, and the first Friday of a biweek, 8:30 am – 5:30 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kevin Teska can be reached on (703) 305-9704. Any response to this office action should be mailed to:

Director of Patents and Trademarks
Washington, DC 20231

Hand-delivered responses should be brought to the following office:

4th floor receptionist's office
Crystal Park 2
2121 Crystal Drive
Arlington, VA

The fax phone numbers for the organization where this application or proceeding is assigned are:

All communications: (703) 872-9306

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist, whose telephone number is:

(703) 305-3900.

Ayal I. Sharon

Art Unit 2123

May 19, 2004

KEVIN J. TESKA
SUPERVISORY
PATENT EXAMINER